SPOTTED OWL MONITORING IN OLYMPIC NATIONAL PARK: 2014 ANNUAL REPORT

Prepared by Scott Gremel
Olympic National Park
600 East Park Avenue
Port Angeles, WA 98362
Scott_Gremel@nps.gov

Cover Photograph: Juvenile spotted owls outside a cavity nest in a Pacific silver fir, in the Dosewallips River drainage. Photo by Rachel Bakerian, NPS.

TABLE OF CONTENTS

EXECUTIVE SUMMARY 1

INTRODUCTION 2

2014 RESULTS 3
- General Monitoring and Site Status 3
- Nest and Reproductive Monitoring 6
- Banding and Capture 7
- Juvenile Dispersal 7
- Barred Owls 7
- Field Recorders 10
- Other Species 10

DISCUSSION 11

COOPERATIVE EFFORTS 12
- 2009/2014 Spotted Owl Demography Workshops 12
- Northern Spotted Owl Presence/Absence Monitoring 12
- Other Interagency Activities and Outreach 13

BUDGET 13

ACKNOWLEDGEMENTS 13

LITERATURE CITED 13

APPENDIX 1- Nest Success 16

APPENDIX 2- IBP Owl Survey Results 17

EXECUTIVE SUMMARY

This report summarizes progress on the northern spotted owl (*Strix occidentalis caurina*) monitoring program in Olympic National Park (ONP) in 2014. Monitored spotted owl territories in the national park, together with those visited by U.S. Forest Service Pacific Northwest Research Station in the surrounding Olympic National Forest, make up the Olympic Peninsula Demographic Study Area. This is one of eight study areas called for in the Northwest Forest Plan to estimate spotted owl population trends and monitor the effectiveness of the plan. Spotted owl territories in the NPS portion of the study have now been monitored an average of over 22 years.

In 2014, National Park Service personnel monitored and managed data on a sample of 52 spotted owl territories (hereafter "sites") to measure survival and reproductive rates, as well as site occupancy status. Crews made 233 visits to these sites, detecting spotted owl pairs at four and single spotted owls at six. This was the lowest proportion of sites with detections of spotted owls for any year of this study. At the ten sites where spotted owls responded, they were found on an average of 58% of monitoring visits. We documented four nest attempts and all were successful, fledging a total of six young. ONP crews banded three new adult spotted owls, one subadult, and one juvenile.

Data collected on the eleven northern spotted owl demography studies 1990-2008 were analyzed at a workshop in Corvallis, OR in January of 2009. This analysis estimated a range-wide rate of population decline of 2.9% a year, and a 4.3% annual decline for the Olympic Peninsula. Female fecundity appeared stable in the Olympics, but the more important estimate of adult survival was declining here and on nine of 10 other areas studied. Results are still being compiled from the meta-analysis of spotted owl data held in January of 2014.

Barred owls (*Strix varia*) were first documented on the Olympic Peninsula in 1985, and have now been detected within 800 meters of 92% of the monitored spotted owl sites in ONP. Competition with this species is now the primary threat to the conservation of spotted owls in protected areas. Occupancy rates of spotted owls in ONP have declined significantly following the first detection of barred owls at a site. Spotted owls that have persisted on territories following detections of barred owls have both moved farther and increased in elevation relative to sites where barred owls are absent. Although barred owls now occupy portions of most spotted owl territories here, most remaining spotted owls are found greater than 800 meters from any previous barred owl detection. While spotted owls have shown the ability to move within their territories to avoid barred owl competition, barred owls occupy new portions of some spotted owl sites each year and the area available to spotted owls continues to be reduced. Models suggest that barred owls are less likely to occupy spotted owl sites on the steepest, driest slopes, and the movement of spotted owls to the steepest portions of their territories is making access and complete survey of the remaining activity centers more difficult.

INTRODUCTION

Olympic National Park (ONP) is located on the Olympic Peninsula in northwest Washington State. The park consists of 922,653 acres, of which roughly 756,000 acres are forested valleys naturally fragmented by high elevation peaks and ridges. Due to the lack of historic timber harvest or recent stand-replacing natural disturbance, most of the forested landscape is dominated by stands older than 100 years. There is a steep precipitation gradient from rainforest valleys in the southwest to rainshadow areas in the northeast, resulting in two very different habitat strata. Drier, east-side forests tend to be younger and dominated by Douglas-fir (*Pseudotsuga menziesii*). West-side forests have a lower frequency of fire and contain more shade-tolerant species such as western red-cedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), and Pacific silver fir (*Abies amabilis*), with varying amounts of Douglas-fir.

The Olympic Peninsula Demography Study is one of eight areas where demographic rates are monitored to assess the effectiveness of the Northwest Forest Plan in preventing a further decline in spotted owl populations. This area consists of 54 northern spotted owl (hereafter spotted owl) sites monitored by National Park Service crews in Olympic National Park and 45 sites monitored by U.S. Forest Service Pacific Northwest Research Station (PNW) crews in the surrounding Olympic National Forest. Each "site" is roughly equivalent to a spotted owl territory, and can have multiple activity centers occupied by spotted owls in different years up to 2 or more kilometers from the initial activity center. Site selection for the ONP portion of the study was not strictly random. Initially, all known sites were monitored. As additional sites were located in the course of surveying randomly located inventory plots, these were added to the sample if they were within a one day hike of a site already being monitored. Forty percent of the current sample of sites were monitored by 1990 and no sites were added or dropped after 1996. Funding and the logistics involved in monitoring sites as far as 24 miles from a trailhead determined the total number of sites that were feasible to monitor and we have continued to monitor sites regardless of their occupancy status.

This study area, including both Park and Forest Service managed lands, is generally representative of habitat conditions on federal lands on the Olympic Peninsula, although the proportion of suitable habitat in the study area is somewhat higher than outside, owing to the higher proportion of National Park land (Appendix F, Anthony et al., 2006). It is not representative of state, private and tribal lands on the Olympic Peninsula, where there is little suitable habitat and few or no remaining spotted owls.

This report summarizes results of fieldwork, cooperative efforts and administration of National Park Service run portion of Olympic Peninsula Demography Study during the 2014 breeding season. It is intended as a summary of results for administrators and cooperators, but does not present detailed methodologies or data analysis. In general, crews make daylong visits to historically occupied spotted owl territories calling for spotted owls. Spotted owls are color banded, and mark-recapture methods are used to calculate survival rates and

population trends based on resighting histories of these banded owls. Behavior of the owls when they are offered live mice allows the determination of nesting and reproductive status. More detailed methods are described in Franklin et al. (1996).

Results through 2012 from the PNW Forest Service administered portion of the Olympic Peninsula study are available at:
http://www.fs.fed.us/pnw/olympia/wet/team-research/owl-res/index.shtml

Reports from most cooperators in the Northwest Forest Plan's Northern Spotted Owl Effectiveness Monitoring Program are available at:
http://www.reo.gov/monitoring/reports/northen-spotted-owl-reports-publications.shtml

ONP provides a unique opportunity to understand the ecology of the northern spotted owl in a large area of suitable habitat with almost no history of timber harvest. The specific objectives of this monitoring program are to:

1) Contribute to a range-wide assessment of spotted owl population trends, as required by the effectiveness monitoring component of the Northwest Forest Plan.

2) Monitor the effects of increasing barred owl populations on spotted owls.

2014 RESULTS

General Monitoring and Site Status

The project employed 7 full or part-time biological aids and technicians, one intern and the project lead. Crews made 233 visits to the 54 monitored spotted owl sites (site locations and occupancy status, Figure 1) and the mean number of visits per site was 4.3 (range 1-7). Two of these sites were formerly monitored by PNW, and they continue to manage those data. We report these site visits here, but the sample size for most analyses is 52 except where noted. Most visits (89%) were daytime searches where crews focused their efforts on recently occupied activity centers, covering suitable habitat out to 2 km as time permitted. The remaining visits were night or twilight surveys from roads or trails. The full field crew (4 one or two-person teams) visited owl sites between March 25 and July 8, with just 2 additional visits in mid-July.

Winter snow water equivalent reached close to 90% of normal by the end of April, but there was little snow at owl sites below 2500' elevation (USDA Natural Resource Conservation Service, snowcourse and SNOTEL data). The early field season had above average precipitation, but June and July were quite dry, and temperatures for the entire period were above average (National Weather Service, Elwha Ranger Station Co-op weather station data).

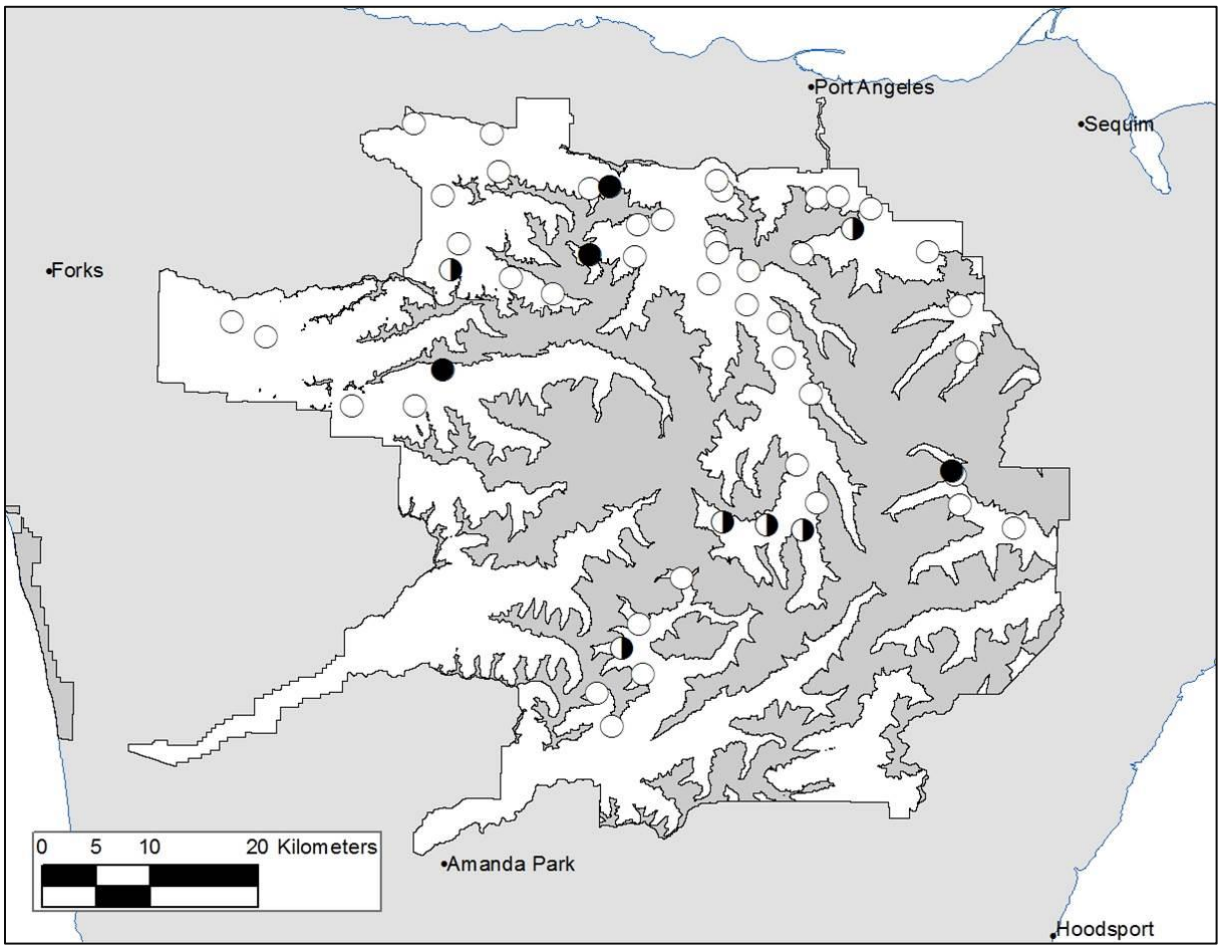

Figure 1. Location and occupancy status of 52 monitored spotted owl territories in Olympic National Park, 2014. Black circles are spotted owl pairs, half-filled circles are single owls and white circles are monitored sites with no response. Shaded area within the park boundary is high elevation non-habitat.

Precipitation was recorded on 31% of site visits in the form of snow (4%) and rain or drizzle (27%). With low snowpack and no new access problems, we completed at least one visit to 52 of 54 sites prior to May 15, the end of the nesting season.

We detected 14 non-juvenile spotted owls this season: five females, seven males and two of unknown sex. Of the 12 spotted owls identified to age class, two were subadults and ten were adults three years of age or older. One or more spotted owls were detected at 10 monitored sites and pairs were located at four of these (Figure 2). This is the fourth consecutive year that we detected more single owls than pairs. Over the last five years 24 sites have been occupied at least once by a pair or resident single. The per visit detection rate at sites where spotted owls were found this year was 58%, which is a close to the 20 year average of 61%.

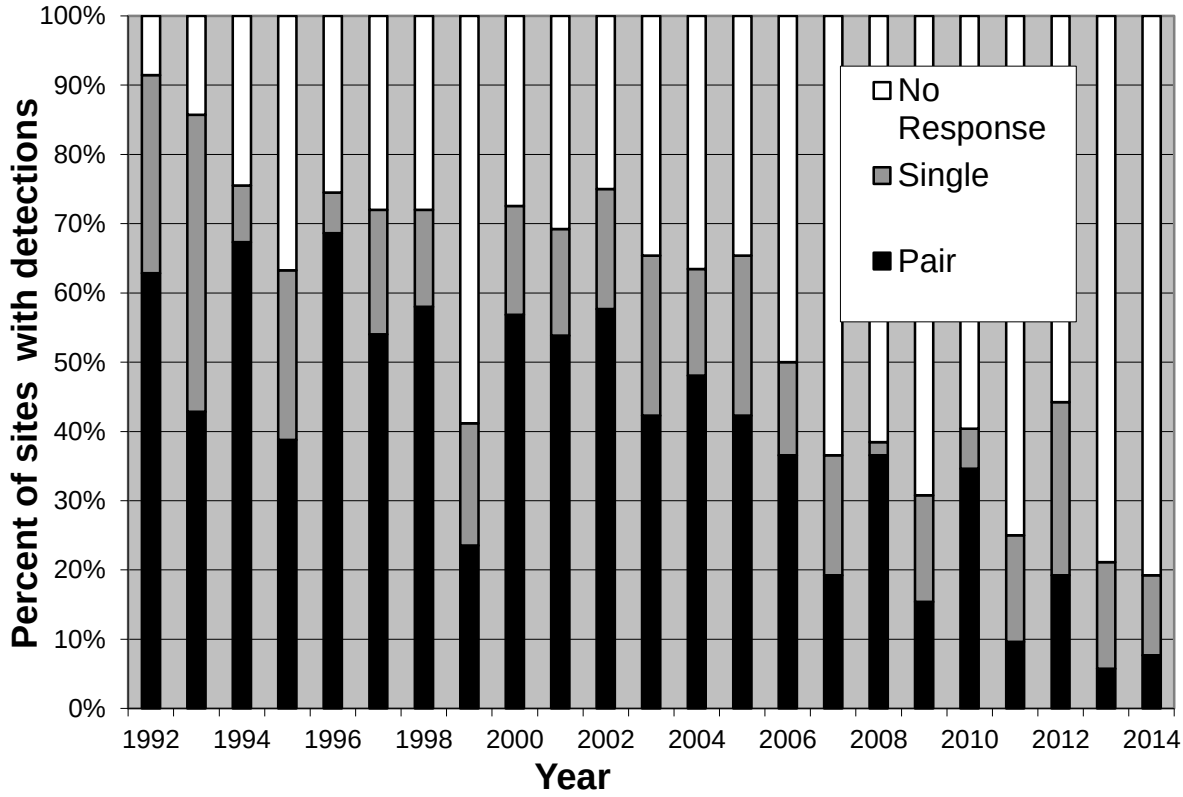

Figure 2. Percent of monitored spotted owl sites with 0, 1, or 2 adult owls detected, Olympic National Park, 1992-2014.

The 52 spotted owl sites monitored in 2014 represented a sample of roughly 23% of the 229 spotted owl territories estimated to occur in ONP as of 1995 (Seaman et al., 1996). The mean length of record is now 22.4 years (range 19-23), not including years prior to 1992 when monitoring to current protocols began at most sites.

Since 1994, the mean elevation of occupied spotted owl activity centers has increased 508' to 2634' and the mean slope within 200 meters has increased from 24° to 30° (when calculated on the 49 sites monitored in both 1994 and 2014). These changes result from both declining occupancy at sites that are lower in elevation and less steep, and the movement of spotted owls to the steeper and higher elevation areas within monitored sites. While there is clearly a relationship between elevation and the likelihood that a spotted owl site has remained occupied, models indicate that slope and topographic moisture explain more of the variance in occupancy than elevation alone (Gremel, 2005). It is likely that these topographic variables are simply correlates for barred owl occupancy (see later section). Regardless of the factors responsible, spotted owl distribution in the Olympics has changed dramatically over the course of this study. This has implications for both conservation efforts and our ability to monitor spotted owl sites safely and effectively.

Nest and Reproductive Monitoring

Spotted owl productivity (fecundity) is calculated as the number of female young produced per territorial female, assuming a 50:50 sex ratio of offspring. Four of the five female spotted owls found on monitored territories attempted to nest and all were successful, fledging a total of six young. This equates to an average annual fecundity of 0.60. Spotted owl fecundity in the Olympics has been highly variable, with years of high productivity often followed by a year with few or no nesting attempts. We documented no successful reproduction in eight of the last 23 years (Figure 3). The high year-to-year variation in female fecundity has been

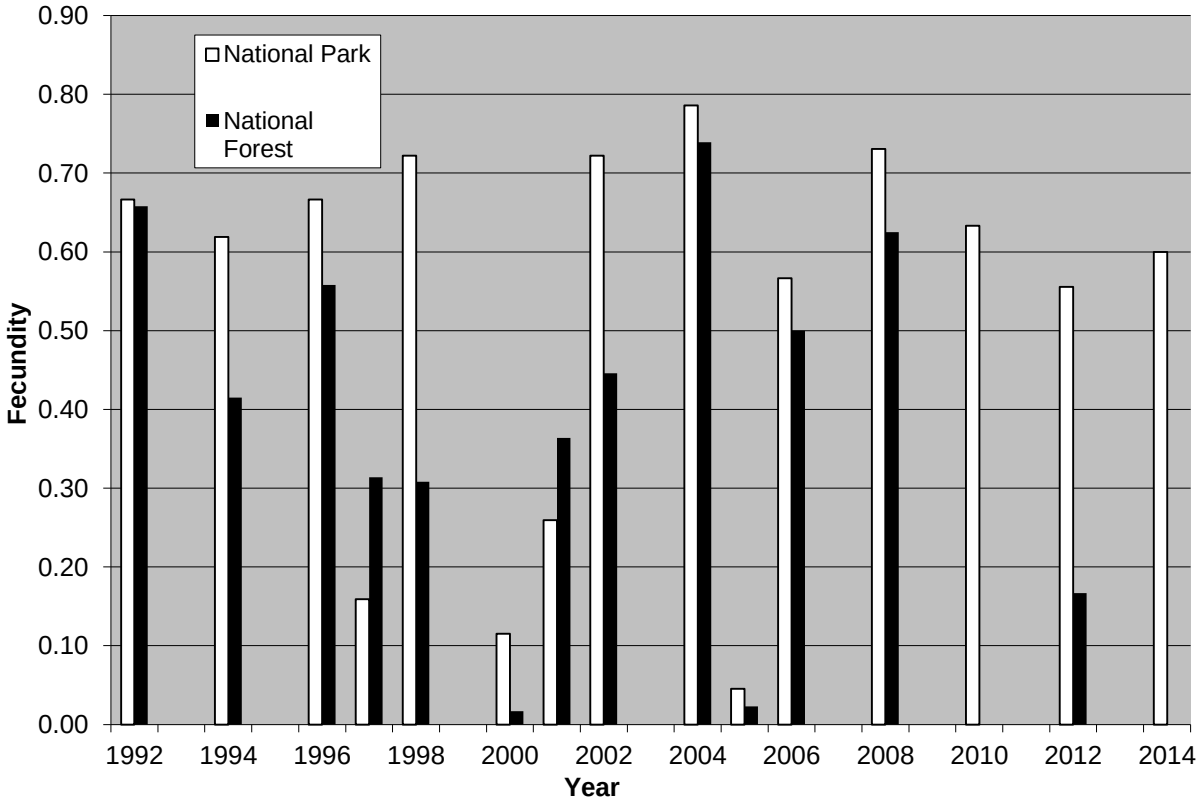

Figure 3. Olympic Peninsula adult spotted owl fecundity (mean # of female offspring/ territorial female), 1992-2014. Includes both National Park (white bars) and National Forest (black bars). No data from the National Forest in 2014.

driven by the proportion of the population attempting to nest, and to a lesser extent the productivity of those nests, rather than the rate of nest success which has averaged 91% (Appendix 1). The mean annual fecundity rate for adult female spotted owls in ONP (N = 23 years) was 0.34 (SE 0.067), and the estimate over the range of the northern spotted owl was 0.33 (SE 0.025) (Forsman, et al., 2011). It is important to note that this estimate is the rate per adult female spotted owl, and is derived from a decreasing number of individuals. The actual

number of juveniles produced in the study area this year (6) is much lower than it was 1994-2004 when 30-40 juveniles fledged from monitored sites in average nesting seasons.

Banding and Capture

Banding owls is necessary to identify individuals and estimate survival rates. All captured owls are fitted with a unique U.S. Fish and Wildlife Service number band and a color band. Adult and sub-adult owls are marked with a color band unique to a 16-km radius from the capture site, which enables field crews to identify these individuals without recapturing them. Juveniles receive a standard color band, which is changed if these birds are re-captured as adults on a new territory. We use established capture techniques for spotted owls (Franklin et al., 1996), and emphasize owl safety during training.

ONP crews captured and banded five spotted owls in 2014: three adults, one subadult, and one juvenile. Of 14 adult/subadult spotted owls detected at monitored sites, four were newly banded in 2014, eight were "recaptures" based on sightings of marked owls from previous seasons and two were unknown owls detected only on night surveys. Since 1988, ONP crews have performed 547 captures and banded 399 spotted owls. We captured and banded under ONP master station banding permit 22633 and U.S. Fish and Wildlife Service 10(a)(1)(a) "take" permit TE842449-5.

Juvenile Dispersal

We did not recapture any juveniles banded in previous years. Nineteen of the 170 spotted owls banded as juveniles by ONP crews prior to 2014 have been recaptured as adults or sub-adults on the Olympic Peninsula. Five dispersed to Olympic National Forest, the others were found within ONP. The median dispersal distance for this sample was 15.8 km (mean 19.1 km, SD 10.0, range 5.3-41.8 km). The mean dispersal distance of females was 44% greater than that of males, but this difference was not statistically significant. The greater dispersal distance for females is consistent with results reported by Forsman et al. (2002) for a large sample of juveniles in Washington and Oregon. The mean age at recapture was 3.2 years, implying that most spotted owls spend several years as non-territorial "floaters" or on territories outside of our study sites before being detected. To date, we have documented no dispersal of spotted owls between the Olympic Peninsula and any of the study areas in the Washington Cascades.

Barred Owls

The first documented occurrence of barred owls on the Olympic Peninsula was on the west side of ONP in 1985 (Sharpe, 1989). This species now occurs across the entire range of the northern spotted owl and is considered to be the greatest threat to spotted owl conservation within protected reserves. Barred owls are dominant in competitive interactions with spotted

owls and evidence from many areas suggests that barred owls displace spotted owls from otherwise suitable habitat (Dark et al., 1998; Kelly, 2001; Gremel, 2005; Wiens, 2012). At ONP, rates of pair occupancy have declined at spotted owl sites following the first barred owl detection there. At sites where spotted owls have remained after barred owls were detected, they have both moved farther from their original location and shifted to higher elevations, relative to spotted owl sites without barred owls (Gremel, 2005). While we record all encounters with barred owls in the course of spotted owl monitoring activities, we do not spend extensive time to establish whether a pair or single owl is present.

We recorded barred owls on 65 separate occasions representing an estimated 42 barred owl territories in 2014. We confirmed pairs at 18 of these sites, either by direct observation or the presence of juveniles. Single barred owls were observed at 24 sites and a total of ten juveniles were observed at five sites. An index of barred owl abundance, based on the number of barred owl sites detected divided by the number of spotted owl site visits, is shown in Figure 4. The annual rate of increase in this index, calculated from the log of the slope from 1992-2014, was 10.8%. We did no formal barred owl surveys this year and data from field recordings (next section) are not yet available.

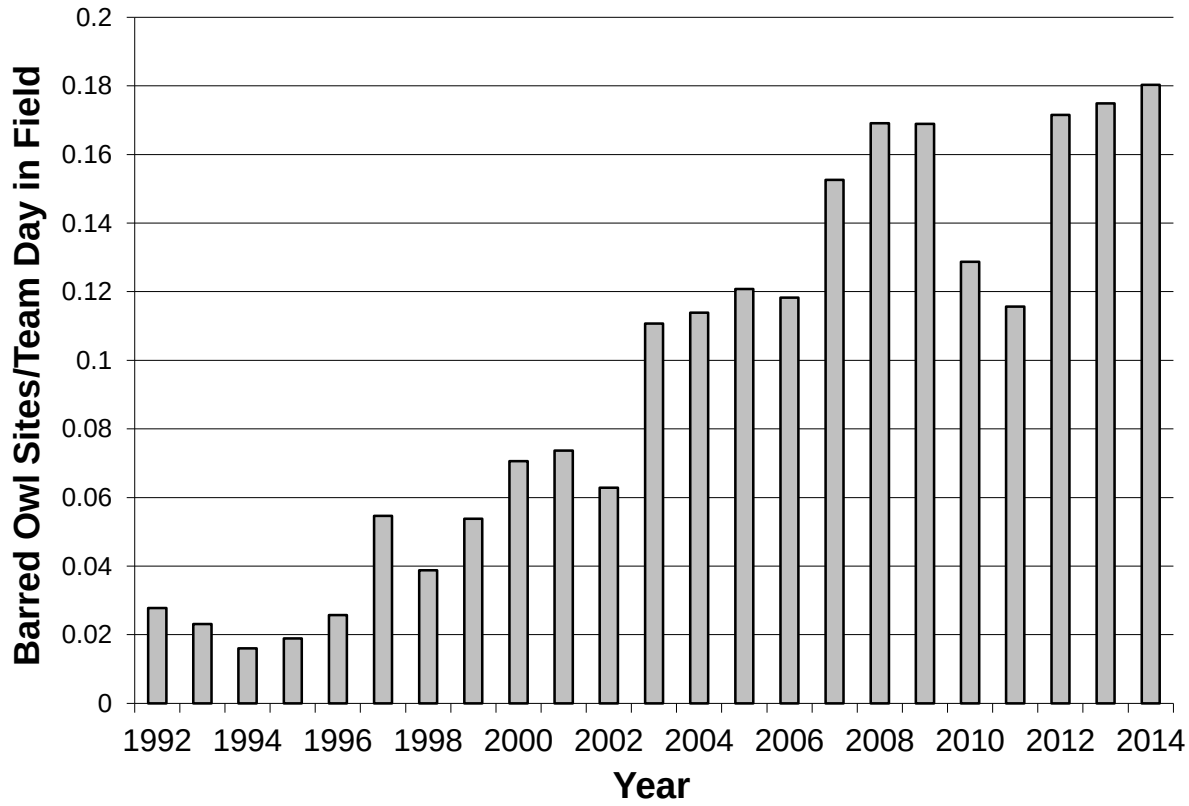

Figure 4. Number of occupied barred owl sites detected, standardized by survey effort, Olympic National Park, 1992-2014. Excludes sites detected as a result of using barred owl calls, radio-telemetry, or acoustic monitoring devices.

An index of barred owl reproduction (the number of juveniles detected/occupied barred owl site) correlated significantly with annual rates of spotted owl fecundity from 1992-2006 at ONP (Spearman's rho = 0.726, $p < 0.01$).

In 2014 we detected barred owls at 34 of 52 monitored spotted owl sites (Fig. 5). Here we define a spotted owl site as the area within 800m of all activity centers occupied between 1990 and 2014. By including both current and former spotted owl activity centers at a site, this definition includes barred owls that may have displaced spotted owls from parts of their former territory. In fact, because spotted owls appear to move away from areas of barred owl activity, the most recent spotted owl locations rarely have barred owls nearby. Barred owls were detected for the first time at one site, and have now been detected at 48 spotted owl sites (92%) in at least one year of the study, and 45 spotted owl sites (87%) in the last three years.

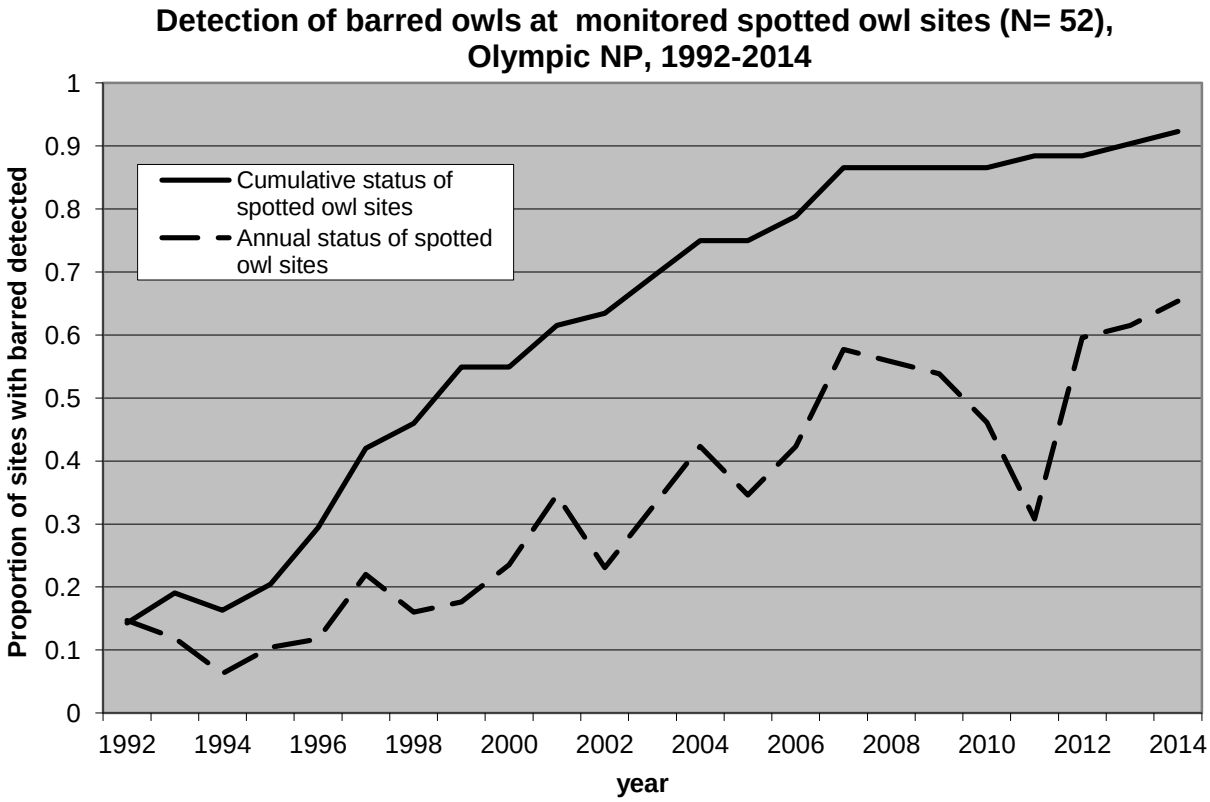

Figure 5. Proportion of monitored spotted owl sites (N=52) with barred owls detected, Olympic N.P., 1992-2014. The solid line is the cumulative proportion of sites where barred owls have ever been detected, and the broken line is the proportion of sites where barred owls were detected in each year during spotted owl monitoring visits.

One occupied spotted owl site was located within 800m of barred owls detected this year, and four additional sites were within 800m of barred owls found in previous years.

Hybridization between barred and spotted owls has been documented, but appears to be infrequent after the initial period of colonization (Hamer et al. 1994; Herter and Hicks, 2000; Kelly and Forsman, 2004). No hybrids were observed this season.

Field Recorders

Since 2010 we have investigated the use of acoustic field recorders to augment the occupancy data derived from the demographic monitoring program. In 2010-2012 we experimented with the use of these recorders at sites with known occupancy by barred and spotted owls to get initial estimates of detection probabilities and develop sampling protocols. In 2013 and 2014 we implemented the protocols at the 21 sites still known to be occupied by spotted owls in 2012. The goals of this acoustic monitoring were to: 1) better estimate the probability of detecting spotted owls with field recorders at sites known to be occupied; 2) track occupancy of both barred and spotted owls with multiple methods (demography site visits and acoustic monitoring) at sites that have recently been occupied by spotted owls.

The sample unit was a four hour recording beginning either 10 minutes before sunset or ending ten minutes after sunrise, recorded in 1 channel at a sample rate of 16 khz. We visually browsed recordings in the program Raven with 8 minute page intervals, noting the presence of all owl species and marbled murrelets. Length of time recorders were left out was based on the logistics of installing and removing the units during our demographic monitoring visits, but was generally a week or more.

In 2013, we installed recorders at 21 spotted owl sites and collected 401 four hour recordings (mean per site 19.1, range 12-34). Spotted owls were detected at nine sites, including three where they were not detected on demography visits. At the 14 sites where spotted owl occupancy was confirmed on either field recorders or monitoring visits, the mean proportion of 4 hour samples with a spotted owl detection was 0.18.

In 2014, we installed recorders at 22 sites, and collected 447 four hour recordings (mean per site 20.3, range 6-34). Two of the older recording units failed this year, requiring multiple deployments at three sites, and resulting in one site with no data and one site with only six samples. Recordings from this season are still being processed.

Other Species

In addition to barred and spotted owls, we also record incidental responses by northern goshawks (*Accipiter gentilis*) and great-horned owls (*Bubo virginianus*). The number of

occupied goshawk sites encountered during owl monitoring has ranged from 0-6 per year. This year we encountered goshawks at five sites, including two pairs and three single birds. We detected a great-horned owl at one site.

DISCUSSION

Since the beginning of the monitoring program in the early 1990's, the proportion of sites where we have detected spotted owls has declined steadily. As recently as 2012 we located at least one spotted owl at 44% of the sites we visited. However barred owls were occupying the historic activity centers at most of these sites, and the spotted owls were often found away from the core areas that they had used in the past. This year we failed to detect spotted owls at over half of the sites where they were found in 2012. With the exception of a single night response by a spotted owl that could not be relocated, there was no evidence of recolonization at any of the sites that were unoccupied in 2012. So the pattern of spotted owl distribution in ONP has been occurrence at a shrinking set of sites, rather than infrequent detections at a larger number of sites over several years. This decline in the area where spotted owls occur continues, as barred owls are found in new parts of some territories each year.

All evidence points to barred owl competition as the cause of the decline in spotted owl numbers at ONP. Although our data on barred owls is imperfect, once we detect barred owls at a spotted owl activity center, the spotted owls rarely persist in that stand. While spotted owls can continue to occupy a territory after barred owls are found nearby, it is usually by shifting their activity center away from the barred owls. At most territories, there is now simply little or no suitable habitat that is not already occupied by barred owls.

Besides the obvious conservation concerns, the occurrence of spotted owls at so few locations should probably lead to an evaluation of whether the current monitoring strategy is the appropriate one for a situation very different from the one twenty years ago. With no evidence of occupancy at 80% of monitored sites, the goal of the majority of site visits is to confirm the absence of spotted owls, or the presence of barred owls, rather than to resight and band owls for the demography study. There may be more efficient ways to monitor spotted owl sites that have been unoccupied for many years than to continue to make three or more daylong visits each year. This could involve a reduced number of annual visits to these sites, or a hybrid approach using field recorders or more comprehensive surveys at longer intervals to monitor for re-occupancy. Reducing the amount of time spent documenting the absence of spotted owls would also allow us to have a smaller, more experienced crew that could focus more time on the sites that remain occupied.

COOPERATIVE EFFORTS

2009/2014 Spotted Owl Demography Workshops

We participated in a meta-analysis workshop held January 5-11, 2014 in Corvallis, OR This was the fifth such analysis to examine data from the spotted owl demography studies being conducted across the range of the species, and it included five additional years of data (2009-2013) collected since the last workshop. Data from federal lands on the Olympic Peninsula (ONP and Olympic National Forest combined) were analyzed along with those from 10 other demographic studies to estimate age-specific rates of fecundity, survival and population trends across the range of the northern spotted owl. For the first time an occupancy analysis was also conducted, which will provide an alternate measure of population trends for both barred and spotted owls. The results from the workshop are still being compiled as of this writing.

Results from the previous workshop, held in January 2009, were published in 2011 (Forsman, et al., 2011). In this analysis, the rate of fecundity on the Olympic Demographic Study Area was stable and best explained by the tendency of spotted owls to reproduce in alternate years (even/odd year effect). Annual apparent survival of territorial females declined over time at Olympic, and at nine of the ten other studies, with declines most pronounced for many areas in recent years. The steepest declines in apparent survival were on the three studies in Washington State. Although varying by year, there was no time trend in annual spotted owl recapture probabilities on the Olympic area, which have generally ranged between 0.6-0.8. Range-wide, the decline in numbers of territorial northern spotted owls was estimated to be 2.9% a year. Point estimates for all studies indicated declining populations, and there was evidence for a statistically significant population decline at seven of eleven studies, including Olympic. The estimated rate of decline on the Olympic demographic study was 4.3% a year. Overall, it appeared that spotted owl populations in Washington were faring worse than those in Oregon and California.

Northern Spotted Owl Presence/Absence Monitoring

Beginning in 2005, spotted owl surveys were implemented as part of a long-term landbird monitoring program in the three large national parks in Washington State: Olympic, North Cascades and Mount Rainier. Crews from The Institute for Bird Populations survey randomly located 1.8 km-long transects, using protocols developed for a spotted owl inventory conducted at ONP in the early 1990s. After conducting point counts for landbirds at stations along these transects, surveyors call for spotted owls at five stations located 400 meters apart. Stations are called for 10 minutes and all stations in forested habitat are called, regardless of elevation. These surveys are providing an inexpensive test of the feasibility and statistical power of implementing a larger scale presence/absence survey, either to complement or replace the current demographic monitoring program.

Overall response rates by spotted owls have been quite low (Appendix 2). No spotted owls were detected on transects this season. Five barred owls were detected on the owl transects either during or after stations were being called, and five more barred owls were recorded by field crews outside of these surveys. Between 2005 and 2014, surveys in the three parks resulted in 7 detections of spotted owls and 36 detections of barred owls on 544 transects.

Other Interagency Activities and Outreach

- Provided records of all field visits to the Washington Department of Fish and Wildlife for a state-wide spotted owl database.

BUDGET

All funding was provided by the NPS through the Regional Ecosystem Office of the Northwest Forest Plan. Funding for spotted owl monitoring was provided at the level of $142,817 in FY 2014. An additional $5000.00 was provided to support NPS participation in northern spotted owl recovery planning, participation in the meta-analysis and regional projects as needed.

ACKNOWLEDGEMENTS

The project is only possible due to the hard work, skill and dedication of the field crew. Declining spotted owl numbers require an increasing number of daylong no response searches in roadless wilderness and often difficult weather conditions. J.A. Ujcic-Ashcroft, D.C. Cole, P.D. Forman, S.A. Gremel, J.D. Herndon, A.R. Hokit, T.J. Kay, E.R. Kohler and P.M. Loafman performed the fieldwork in 2014. Patti Happe, ONP Wildlife Branch Chief, provided overall project supervision and administration, T.J. Kay assisted with coordination and supervision of the field work, and R.A. Hoffman and K.F. Beirne provided GIS support. Liz Kelly of the USFWS generously provided the program used to map barred owl locations relative to spotted owl sites. Jim Swingle, Oregon State University, provided a loan of several field recorders which allowed us to complete acoustic monitoring at all scheduled sites despite two of our units failing.

LITERATURE CITED

Anthony, R.G., E.D. Forsman, A.B. Franklin, D.R. Anderson, K.P. Burnham, G.C. White, C.J. Schwartz, J.D. Nichols, J.E. Hines, G.S. Olson, S.H. Ackers, L.S. Andrews, B.L. Biswell, P.C. Carlson, L.V.Diller, K.M. Dugger, K.E. Fehring, T.L. Fleming, R.P.

Gerhardt, S.A. Gremel, R.J. Gutierrez, P.J. Happe, D.R. Herter, J.M. Higley, R.B. Horn, L.L. Irwin, P.J. Loschl, J.A. Reid and S.G. Sovern. 2006. Status and trends in demography of northern spotted owls, 1985-2003. Wildlife Monographs 163.

Forsman, E. D., R. G. Anthony, K. M. Dugger, E. M. Glenn, A. B. Franklin, G. C. White, C. J. Schwarz, K. P. Burnham, D. R. Anderson, J. D. Nichols, J. E. Hines, J. B. Lint, R. J. Davis, S. H. Ackers, L. S. Andrews, B. L. Biswell, P. C. Carlson, L. V. Diller, S. A.Gremel, D. R. Herter, J. M. Higley, R. B. Horn, J. A. Reid, J. Rockweit, J. Schaberl, T. J. Snetsinger, and S. G. Sovern. 2011. Population Demography of Northern Spotted Owls. Studies in Avian Biology 40.

Dark, S.J., R.J. Gutierrez, and G.I.J. Gould. 1998. The barred owl (Strix varia) invasion in California. The Auk 115(1):50-56.

Forsman, E.D., R.G. Anthony, J.A. Reid, P.J. Loschl, S.G. Sovern, M. Taylor, B.L Biswell, A. Ellingson, E.C. Meslow, G. S. Miller, K.A. Swindle, J.A. Thrailkill, F.F. Wagner, and D.E. Seaman. 2002. Natal and breeding dispersal of northern spotted owls. Wildl. Monog. 149.

Franklin, A.B., D.R. Anderson, E.D. Forsman, K.B. Burnham, and F.W. Wagner. 1996. Methods for collecting and analyzing demographic data on the northern spotted owl. Studies in Avian Biology 17:12-20.

Franklin, A.B., K.P. Burnham, G.C. White, R.G. Anthony, E.D. Forsman, C. Schwarz, J.D. Nichols and J. Hines. 1999. Range-wide status and trends in northern spotted owl populations. Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Corvallis, OR.

Gremel, S.A. 2005. Factors controlling distribution and demography of northern spotted owls in a reserved landscape. MS thesis, University of Washington, Seattle, WA.

Hamer, T.E., E.D. Forsman, A.D. Fuchs, and M.L. Walters. 1994. Hybridization between barred and spotted owls. The Auk 111(2):487-492.

Herter, D.H. and L.L. Hicks. 2000. Barred owl and spotted owl populations and habitat in the central Cascade Range of Washington. J. Raptor Res. 34(4):279-286.

Kelly, E.G. 2001. The range expansion of the Northern Barred Owl: An evaluation of the impact on Spotted Owls. MS Thesis, Oregon State University, Corvallis, OR.

Kelly, E.G. and E.D. Forsman. 2004. Recent records of hybridization between barred owls and northern spotted owls. The Auk 121(3):806-810.

National Weather Service COOP Weather Station, Elwha Ranger Station, Washington (452548). Available at: http://www.wrcc.dri.edu/summary/Climsmwa.html. Accessed on Aug. 11, 2014.

Seaman, D.E., S.A. Gremel, S.L. Roberts, and D.W. Smith. 1996. Spotted owl inventory-monitoring in Olympic National Park, final report. Unpubl. NPS report, 34 pp.

Sharpe, D.U. 1989. Range extension of the barred owl in western Washington and first breeding record on the Olympic Peninsula. J. Raptor. Res. 23(4): 179-180.

USDA Natural Resources Conservation Service - SNOTEL Data. Available at: http://www.wcc.nrcs.usda.gov/nwcc/site?sitenum=974&state=wa. Accessed on Aug. 11, 2014.

USDA Natural Resources Conservation Service - Snow Course Data. Available at: http://www.wcc.nrcs.usda.gov/nwcc/snow-course-sites.jsp?state=WA. Accessed on Aug. 11, 2014.

Wiens, J.D. 2012. Competitive interactions and resource partitioning between Northern Spotted Owls and Barred Owls in western Oregon. PhD dissertation, Oregon State University, Corvallis, OR

APPENDIX 1- Nest Success

Nesting status and success rate of female spotted owls of all age classes, at monitored sites in Olympic National Park, 1992-2014.

	Non-nesting	Nesting	Unknown nest status	Total females	Proportion nest status known	Proportion females nesting	Nest success[1]
1992	1	15	7	23	0.70	0.94	0.93
1993	16		5	21	0.76	0	*
1994	3	24	7	34	0.79	0.89	0.92
1995	15		6	21	0.71	0	*
1996	5	28	3	36	0.92	0.85	0.92
1997	15	8	6	29	0.79	0.35	0.75
1998	1	24	5	30	0.83	0.96	0.91
1999	9		5	14	0.64	0	*
2000	17	10	4	31	0.87	0.37	0.56
2001	16	8	4	28	0.86	0.33	1.00
2002	3	27		30	1.00	0.90	0.92
2003	23		2	25	0.92	0	*
2004	2	21	4	27	0.85	0.91	0.95
2005	20	1	3	24	0.88	0.05	1.00
2006	1	16	2	19	0.89	0.94	0.94
2007	13		1	14	0.93	0	*
2008	1	16	2	19	0.89	0.94	0.94
2009	8		1	9	0.89	0	*
2010	4	14		18	1.00	0.78	0.93
2011	5		1	6	0.83	0	*
2012	2	7	2	11	0.82	0.78	1.00
2013	3		1	4	0.75	0	*
2014	1	4		5	1.00	0.80	1.00
Total[2]	184	223	71	478	0.85	0.47	0.91

[1] Proportion of nest attempts that result in at least one fledgling, calculated on nests with known outcomes

[2] Where totals are calculated on proportions, they are the unweighted averages of the annual means

APPENDIX 2- IBP Owl Survey Results

Results of presence/absence owl surveys performed by The Institute for Bird Populations' landbird monitoring crews. This includes barred and spotted owls detected at or associated with owl calling stations, as well as incidental detections outside of formal survey or while conducting point counts. Multiple owls at a point are recorded as a single detection.

Year	National Park	Transects Called	Stations Called	Barred Owl Detections			Spotted Owl Detections		
				At Stations	Between Stations	Incidental	At Stations	Between Stations	Incidental
2005	Mt. Rainier	9	40	0	1	0	0	0	0
	N. Cascades	11	53	0	0	0	0	0	0
	Olympic	8	34	0	0	0	0	0	1
2006	N. Cascades	12	57	1	1	0	1	0	0
	Olympic	10	44	3	0	0	1	0	0
2007	Mt. Rainier	19	114	0	1	1	0	0	0
	N. Cascades	22	104	2	1	2	0	0	0
	Olympic	21	95	0	0	0	0	0	0
2008	Mt. Rainier	20	94	1	1	0	0	0	0
	N. Cascades	20	96	3	0	0	0	0	0
	Olympic	21	95	0	0	3	1	1	0
2009	Mt. Rainier	16	69	1	0	0	0	0	0
	N. Cascades	23	97	0	0	0	0	0	0
	Olympic	22	91	2	0	2	1	0	1
2010	Mt. Rainier	17	74	1	0	0	0	0	0
	N. Cascades	19	80	1	0	0	0	0	0
	Olympic	22	95	0	0	1	1	0	0
2011	Mt. Rainier	12	50	1	1	1	0	0	0
	N. Cascades	21	101	2	0	1	0	0	0
	Olympic	20	93	0	0	4	0	0	0
2012	Mt. Rainier	20	99	1	0	0	0	0	0
	N. Cascades	24	114	4	0	3	0	0	0
	Olympic	24	114	0	0	2	0	0	0
2013	Mt. Rainier	19	85	1	0	0	0	0	0
	N. Cascades	23	104	0	0	6	0	0	0
	Olympic	24	116	1	0	0	1	0	0
2014	Mt. Rainier	19	87	1	1	2	0	0	0
	N. Cascades	23	114	0	0	1	0	0	0
	Olympic	23	108	3	0	2	0	0	0
	Totals	544	2517	29	7	31	6	1	2